Residential Fuel Cell Test Facility

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Project Goals

- Accelerate the widespread commercialization of fuel cells in building applications
- Provide consumers with accurate, easy-to-understand information on financial costs and benefits of fuel cells
- Provide feedback to fuel cell manufacturers on overall performance of fuel cell systems under varying environmental, thermal, and electrical load conditions

Introduction

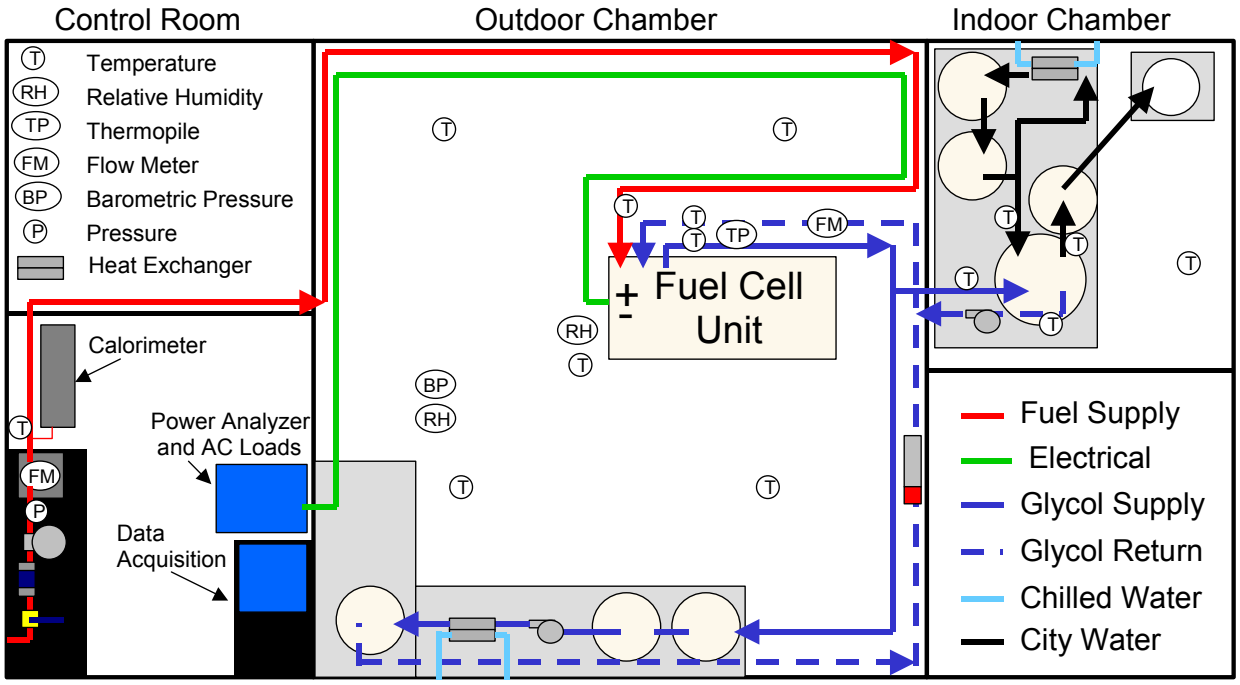
The National Institute of Standards and Technology's (NIST) Residential Fuel Cell Test Facility will be used to determine the seasonal performance of residential fuel cell systems for the development of a consumer-oriented performance rating. A rating such as this will help guide consumers in their economic decisions and is essential to the widespread commercialization of residential fuel cell systems.

NIST seeks to accelerate the commercialization of residential fuel cells by developing a methodology for determining the seasonal performance of residential and small commercial fuel cell systems. This methodology would aid the purchaser of a residential fuel cell in determining the economic impact of such a system, and would provide a combined metric of the seasonal performance of the electrical and thermal outputs of a specific fuel cell system. NIST desires to supplement the efforts of many consensus standards organizations and their respective performance standards, such as ASME and ANSI, with a test procedure and rating methodology that accounts for any change in performance as a function of the environmental conditions, electrical load, and thermal load. Using the Residential Fuel Cell Test Facility, a battery of tests will be performed to determine the electrical and thermal efficiency at various ambient temperatures, relative humidity levels, thermal loads, and electrical loads. The results will help form a draft test procedure and rating methodology that will be submitted to a consensus standards organization for review, refinement, and acceptance by a committee of industry, academic, and government representatives.

Test Facility Description

The NIST Residential Fuel Cell Test Facility measures the fuel energy provided to the system and the electrical and thermal energy output by the system; essentially treating the fuel cell as a "black box". The test facility consists of three rooms: a large environmental chamber, a smaller environmental chamber, and a control room. The large chamber is controlled to approximate outdoor environmental conditions, and houses fuel cell equipment that would typically be installed outdoors. The small environmental chamber is controlled to maintain indoor environmental conditions. Equipment such as water heaters for domestic hot water heating applications and pumps are installed in the indoor chamber. The control room holds all of the data acquisition equipment, electrical loads used to dissipate the electrical energy when the systems is operated independent of the electrical grid, and equipment to measure the energy content of the fuel. Currently, a commercially available residential fuel cell is installed in the test facility. The fuel cell produces 5 kW of power at 120 VAC, uses natural gas as its fuel, and can produce approximately 9 kW of thermal energy. The unit can be grid interconnected or can supply energy to dedicated electrical loads.

Plug Power *Gensys 5c* Installed in NIST's Residential Fuel Cell Test Facility



Residential Fuel Cell Test Facility Schematic

Four major systems comprise the test facility: environmental system, fuel energy system, electrical energy system, and the thermal energy system. The environmental system measures and controls the ambient temperature and relative humidity in each of the chambers. The fuel system measures the fuel energy consumed by the fuel cell using a calorimeter that determines the energy content of the fuel and a positive-displacement gas meter that measures the volume of gas consumed. The electrical output of the fuel cell can be dissipated to the local utility grid or to a set of programmable AC loads. The electrical energy system uses power analyzers to measure both of these outputs. The thermal energy from the fuel cell can also be dissipated in two different manners. First, a fluid conditioning loop is able to extract heat from the fuel cell while maintaining a constant inlet temperature and flow rate, which are both variable. Second, the thermal energy of the fuel cell can be used to preheat potable water for inlet into a standard electrical water heater, which requires less electricity to maintain its temperature due to the preheated water. Both the fluid conditioning loop and the domestic hot water loop are equipped with volumetric flow meters and temperature measurement devices to determine the quantity of thermal energy provided by the fuel cell. The electrical and thermal efficiency of the residential fuel cell can be calculated using the measured electrical and thermal energy output as well as the fuel energy consumed by the unit.

Testing Methodology

Several types of tests will be performed to determine the effects of operating mode on the fuel cell's performance, see table below. For each of these tests, the ambient temperature, relative humidity, electrical load level, and thermal load level will be varied. After the effects of operational mode, environmental conditions, electrical load level, and thermal load level have been established, sound engineering judgment will determine the minimum number of tests, electrical load levels, thermal load levels, and environmental conditions that will provide an adequate portrayal of the overall performance of the fuel cell unit. This subset of tests and conditions will be drafted into a test procedure document that will then be submitted to a consensus standards organization for review and refinement. A rating methodology will use of the data from the test procedure to predict the electrical and thermal output as well as the amount of fuel consumed. When coupled with prices for natural gas and electricity, this will provide residential fuel cell purchasers with a realistic estimate of the financial benefits of fuel cells.

Test Description	Electrical Load	Thermal Load
Steady State Electrical Load	Steady State	None
Steady State Electrical and Thermal Load		Steady State
Steady State Electrical Load and Transient Thermal Load		Transient
Steady State Electrical Load with Thermal Energy Used to Preheat Domestic Hot Water		Domestic Hot Water
Transient Electrical Load	Transient	None
Transient Electrical Load with Steady State Thermal Load		Steady State
Steady Electrical Load During System Startup	Startup	None